Valuing landslide risk reduction programs in the Italian Alps: the effect of visual information on preference stability☆

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Abstract

Climate change has increased the frequency and intensity of weather-related natural hazards everywhere. In particular, mountain areas with dense human settlements, such as the Italian Alps, stand to suffer the costliest consequences from landslides. Options for risk management policies are currently being debated among residents and decision makers. Preference analysis of residents for risk reduction programs is hence needed to inform the policy debate. We use discrete choice experiments to investigate the social demand for landslide protection projects. Given the importance of information in public good valuation via surveys, we explore the effect of specific visual information on the stability of preference estimates. In our survey, we elicit preferences before and after providing respondents with scientific-based information, based on visual simulations of possible events. This enables us to measure information effects. Choice data are used to estimate a Mixed Logit (MXL) model in WTP space to obtain robust estimates of marginal willingness-to-pay (mWTP) estimates and control for the effect of information. Mapping posterior individual specific mWTP estimates provide additional policy implications. Overall, we found the mWTP estimates to be dependent on information.

Keywords: Landslides; Information effect; MXL model in WTP space; Geographical representation; Discrete choice experiments.

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1. Introduction

Climate change has increased the frequency of geo-hydrogeological calamities, over both time and space. Worldwide a growing number of people are affected by such natural phenomena. This study specifically addresses landslides in the Italian Alps, an area where landslides are an increasingly common major natural hazard. They are complex events for which current data records provide no precise estimations of risk; scientists are hence unable to provide accurate predictions of probability of occurrence. In the engineering literature, there have been several proposals of technical solutions aimed to reduce the impacts of landslide events (Berti et al., 1999; Gregoretti and Dalla Fontana, 2008; D'Agostino et al., 2010). Most solutions consist of specific safety devices to mitigate the risk in pre-existing landslides' trajectories. However, few studies address individuals' preferences to the proposed solutions.

Landslides have been studied extensively in Europe, especially in Italy, Norway, Switzerland and the UK, mainly with a focus on their economic impact. From the analysis of previous literature on this topic, it emerges that few studies employed non-market valuation techniques, and especially stated preference techniques, to estimate the value of landslide risk reductions programs (Ahlheim et al., 2008; Mori et al., 2006; Flügel et al., 2015; Thiene et al., 2016 and Vlaeminck et al., 2016). However, there is still limited work carried out in the investigation on the social acceptability of risk mitigation programs, and on their specific demand.

This study reports the results of a Discrete Choice Experiment (hereafter DCE) for the evaluation of landslide protection devices. This approach is well suited for such analysis as it allows researchers to elicit individuals' preferences for alternative policy measures.

The present investigation contributes to the small literature on people's preferences for landslide mitigation programs. Specifically, we estimate the implied willingness-to-pay (WTP) of the local population of visitors and residents of the Boite Valley (Belluno, Italy) inferring it from a sample. The WTP estimates concern different engineering solutions designed to increase safety from potential landslides. To develop preferences over the alternative solutions, the population during the debate should be exposed to scientific-based information such as hydro-geological simulations of possible events. So, we also test whether the provision of visual information affects the stability of our estimates of respondents' preferences. In particular, we focus on detecting whether information about a safety device increases individuals' WTP for that specific device. This is particularly relevant from a policy perspective, as it may help policymakers to evaluate whether it is appropriate to allocate resources in promoting information campaigns. This analysis is grounded on previous literature that showed that WTP estimates are impacted by the type of information provided to respondents (Munro and Hanley, 2002; Chanel et al., 2006; MacMillan et al., 2006; Oppewal et al., 2010). Furthermore, uninformed respondents may underestimate benefits of protection projects for the community. Finally, to explore the validity of our results, we map the mean values of marginal WTP estimates at the individual level within each municipality. To our knowledge, the analysis of how the sample estimates of marginal WTP are distributed over space has not been previously employed to evaluate alternative risk management policies.

The remainder of this paper is organized in four sections. Section 2 presents the case study by giving the reader an overview of the landslide hazard, the policy context of the study and presenting the hypotheses to be tested. Section 3 describes the survey design and the modelling approach used for the data analysis and the hypotheses' tests. In section 4 we discuss the results, including the geographical representations of the respondent-specific marginal WTP estimates. Finally, our conclusions are reported in section 5 along with the policy implications for landslide risk mitigation in the Boite Valley.

2. The case study

2.1 *The case study and policy debate*

In the steep mountain areas of the Dolomites (North-East of Italy) there is substantial evidence of recent and past landslide occurrences. The high vulnerability of this area to landslides, especially debris-flows, is likely to be exacerbated by future climate change. The local population are exposed to the risk of serious socio-economic consequences from these natural events. Historical records show that they often resulted in fatalities, homelessness, damaged buildings and interrupted road traffic (Sterlacchini et al., 2007; Salvati et al., 2010). These occurrences harshly affect the main local industry, which is based on tourism. Due to high hydrogeological risk levels, several landslides occurred in the Boite Valley – the specific location of our study – and caused deaths and damage to houses and other property. In 1814, a massive landslide destroyed two villages, killing 257 people. The biggest events happened in 1925, causing 288 victims and 53 people went missing. In the last decade, this area suffered a series of devastating landslides. Recently, in summer 2015, intense rainfall over a short period of time triggered eight events, causing significant damage to public infrastructure and three victims among visitors. Geologists believe that there are approximately 350 potential and active landslides that can be highly dangerous for the population living in the valley (Guidoboni and Valensise, 2014).

Local authorities are still debating with the community what possible landslide risk mitigating options to undertake. A large scale evaluation of both public support and acceptability for alternative risk reducing programs is underway. This is because: i) realization costs are high and many roads and municipalities are at risk; ii) protection devices could have major environmental impacts; and iii) major changes of the municipalities' planning are expected.

2.2 *Hypotheses*

This paper specifically investigates the following three hypotheses:

H1: People perceive the current level of protection from landslide hazard as inadequate.

Because of recent landslide events, it is clear that risk mitigation is still a major safety issue for local authorities in the Boite Valley. However, interventions to mitigate the risk are expensive to implement. A unanimous decision about the measures to be adopted in the valley has not yet been reached. Therefore, there is a need for better understanding public acceptability of landslide risk management for an efficient use of public funds. For this reason, it seems useful to acquire additional information on preferences of residents and visitors, given that they would be the main beneficiaries, but also they would be the main financial contributors. The inclusion of social preferences in the public debate allows policy makers to take into account the economic dimension (expressed in terms of WTP), in addition to the other dimensions that feed into such debate. Specifically, preferences regard the use of a range of mitigation devices to increase protection. No previous studies have investigated respondents' preferences among a variety of safety devices against natural hazards.

H2: The provision of specific scientific-based information will positively shift the WTP for the specific attribute for which the information was provided as well as for the other attributes.

Many stated preference researchers investigated information effects on WTP estimates. Findings from previous studies in the context of environmental goods showed controversial results. The majority of the studies found that provision of information about a good leads to changes in WTP estimates. Among them, Munro and Hanley (2002) showed that an individual's WTP increased if positive information about the good was provided. The information effect was also investigated by O'Brien and Teisl (2004) regarding environmental certification and labelling. Their results suggest that additional information considerably altered estimates of mWTP for specific attributes. Instead, the results of a study conducted by Oppewal et al. (2010) suggest that providing explanatory information about an unfamiliar attribute not only results in parameter shifts for the particular attribute but also affects the estimates of the remaining attributes and the scale unit of the utility function. The study conducted by Czajkowski and Hanley (2012) suggested that respondents were more deterministic in their choices when provided with additional information. In a contingent valuation study, Chanel et al. (2006) showed that scientific information could have a positive impact on the respondents' WTP, but not so for public opinion. Other studies focused on the effect of information provision for goods that differ in term of familiarity. Among them, MacMillan et al. (2006) found that half of respondents changed their WTP over successive rounds of information provision, especially for the less familiar good. In our case people might value more those protection measures offering the highest level of safety, such as passive devices, than those offering a lower safety level, such as active devices.

H3: There is spatial heterogeneity in the distribution of the WTP estimates and in the effect of information provision.

Residents in the Boite Valley can, in fact, benefit more for the implementation of landslide mitigation programs than visitors. Therefore, there could be evidence of a distance decay effect. Respondents' familiarity with the problem and exposure to it can lead to different impacts of additional information across the region. We expect a stronger information impact on individuals living far from the Boite Valley, as they are likely to be less aware of the landslide problem of the area.

It is a theoretically well-established expectation that welfare changes display spatial heterogeneity, and that this heterogeneity can be policy relevant in empirical applications. An expanding literature addresses the relevance of spatial factors for the estimation of WTP. Spatial distributions of WTP estimates from DCE surveys have been investigated in several studies, starting from the seminal work by Campbell et al. (2008, 2009) in which WTP estimates for rural landscape features were mapped across the Irish landscape. They revealed that WTP is positively spatially autocorrelated in relation to non-site specific landscape improvements. Similarly, the spatial heterogeneity in WTP for environmental attributes was also investigated by Abildtrup et al. (2013), Broch et al. (2013) and Termansen et al. (2008). Yao et al. (2014) used data on forest distance from respondent's homes found evidence of a significant distance-decay effect, which means that respondents tend to have a higher WTP if living closer to the environmental good evaluated. Additionally, Czajkowski et al. (2016) found that respondents' WTP was higher the closer was their place of residence to the nearest forest, and the scarcer forests were in the surrounding area. They also found that respondents from different regions had different WTP for each attribute.

3. Survey design and data

3.1 *Discrete choice experiment attributes*

We developed a five attributes DCE, described in Table 1. Four attributes represent devices to protect against landslides: two passive devices (diverging channel and retaining basin) and two active ones (video cameras and acoustic sensors). We identified the four technical attributes following the advice of geologists and engineers with the purpose of making the scenarios as realistic as possible. The fifth attribute is a hypothetical road toll to access transit in the valley for a one-time period of approximately eight months to financially support the implementation of the mitigation programs. All attribute levels are dummy-coded (presence of the safety device = 1, else = 0) except the monetary attribute that takes four numeric values.

Attribute	Acronym	Description	Levels
Channel	CHAN	The diverging channel is a man-made channel built to redirect water. The water is carried off in a different way that the sediment and rocks, mitigating the impact of the landslides.	1 if present 0 otherwise
Basin	BAS	Retaining basin is a dam where the solid and liquid mass is collected prior to damage roads and villages.	1 if present 0 otherwise
Video cameras	VIDEO	Video cameras monitor the landslides during the night and, in case of emergency, they will activate the alarm system and the traffic lights on the road.	1 if present 0 otherwise
Acoustic sensors	SENS	Acoustic sensors detect soil movement in slopes prior to landslides. The sensors consist of pipes inserted vertically in the flank of a landslide slope. They provide with acoustic emissions used to give early warnings of landslide occurrence as well as activated the traffic lights.	1 if present 0 otherwise
Road toll	TOLL	A road toll to pay for eight months (from April to November of a specific year) daily for transit in the valley by car for residents and visitors.	€1 €2 €3 €4

Table 1. Attributes and levels of the DCE.

3.2 *Experimental design and questionnaire development*

The generic DCE used an optimised orthogonal experimental design (Ferrini and Scarpa, 2007; Scarpa and Rose, 2008; Rose and Bliemer, 2009; Bliemer and Rose, 2010 and 2011). The unlabelled choice sets design was carried out using the software Ngene (ChoiceMetrics, 2012). A full factorial experimental design for four 2-level attributes and one 4-level attribute provided $2^4 \times 4=64$ combinations of alternatives. A full factorial design permits to identify both the main effect of each attribute and the effect of the interactions between them. However, as the focus of the study was on the main effect of each attribute, a fraction of the full factorial design was adopted. The fractional design consisted of sixty choice sets that were blocked into ten groups of six each. Each respondent could reply to six choice sets from one of the ten blocks to which s/he was randomly assigned. Each choice set comprised seven alternatives among which to choose the preferred option (Figure 1). Among them, the seventh alternative represented the *status quo* (S.Q.) option, i.e. the hypothesis of maintaining the current situation without any additional costs and no safety improvement.

Site 1 - CANCIA

Alternatives	A	B	C	D	E	F	S.Q.
Channel	-	-	-	channel	channel	channel	-
Basin	-	basin	basin	basin	-	-	insuff. basin
Video cameras	video	-	video	-	-	video	-
Acoustic sensors	-	-	sensors	-	sensors	sensors	-
Road toll	€ 3	€ 4	€ 1	€ 1	€ 3	€ 3	€ 0
Your choice							

Figure 1. An example of a choice set for a specific site.

Six locations were selected on the valley, each of them with a high landslide risk. Each choice set presented to respondents explicitly referred to one of these six sites. Therefore, a different *status quo* option was included for each site. In some locations, respondents were informed of the existence of insufficient or under-dimensioned safety devices when these were unable to provide reasonable protection against landslides. Unsafe protection devices were treated as absent in the data analysis, because inactive for protection. To facilitate space awareness, we gave respondents maps of the valley with marked locations of each site. Table 2 reports the actual situation of safety devices in each location.

Sites	Passive devices		Active devices	
	Channel	Basin	Video cameras	Sensors
1. Cancia	absent	insufficient	absent	absent
2. Chiappuzza	insufficient	insufficient	absent	absent
3. Acquabona	absent	present	absent	absent
4. Fiames Km 106	present	absent	absent	absent
5. Fiames Km 108	absent	absent	absent	absent
6. Fiames Km 109	present	insufficient	absent	absent

Table 2. *Status quo* in each site.

The survey consisted of seven sections: the first included warm-up questions followed by questions about attitudes toward risk and knowledge about landslide hazard. The second section asked questions on recreational behaviour. The questionnaire was designed to include a DCE in the third part and a “repeated” DCE in the fifth. A fourth section provided respondents with the information treatment, which consisted of visual representations of hydro-geological simulations of landslides, the effect of which was at the core of our investigation. Debriefing questions were asked in the sixth section investigating preference over payment vehicles and the feeling of urgency of such protective policy measures. The final section of the questionnaire consisted of demographic questions.

The two DCEs before and after the information treatment were identical. Specifically, the additional information was provided in the form of two hydro-geological simulations of possible landslides. The first simulation (Figure 2) referred to three sites in the upper part of the valley and showed all the possible trajectories of the landslides. The second simulation modelled landslide trajectories in a specific site with and without a safety device, the channel. This simulation is reported in Figure 3. The yellow and green areas describe all possible landslide trajectories without the channel. Alternatively, were the channel built, the yellow areas does not constitute possible landslide trajectories.

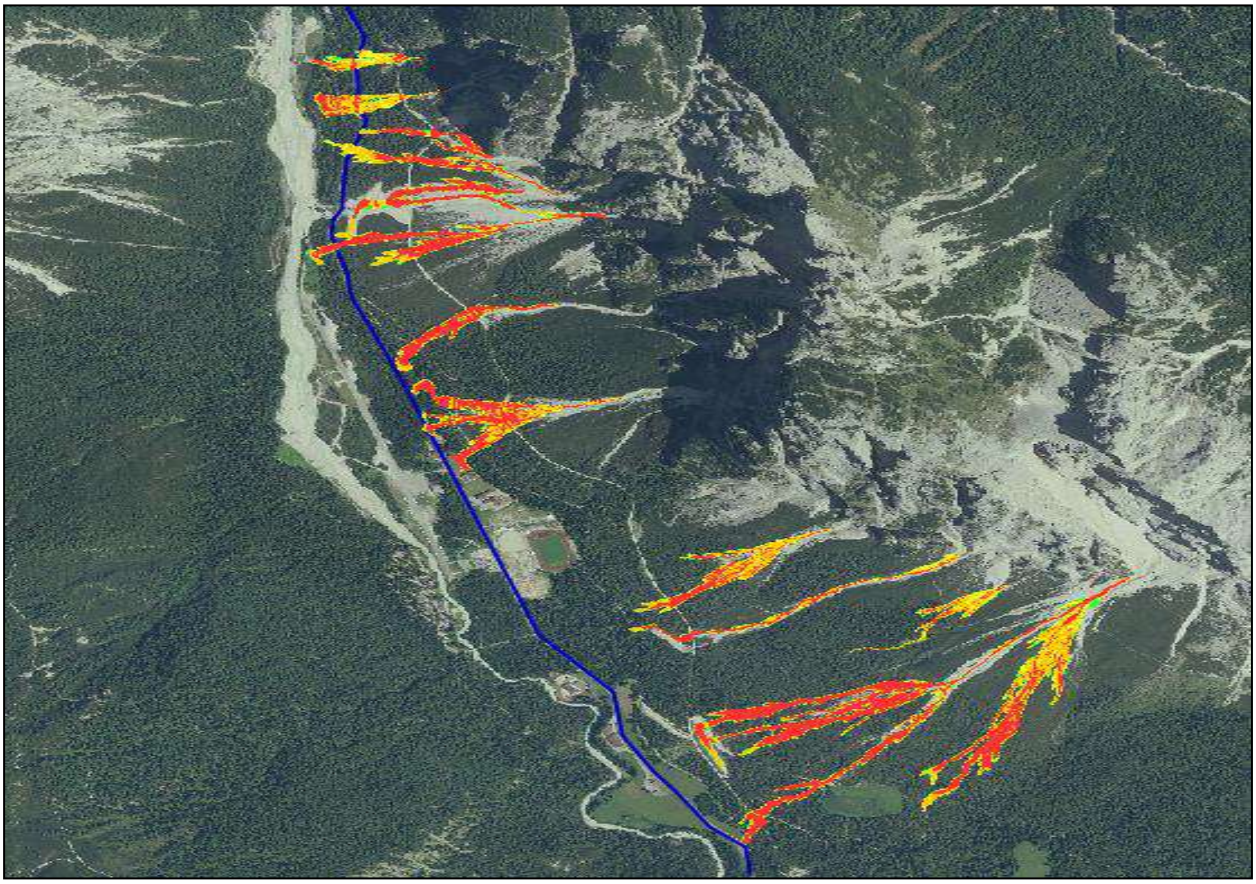

Figure 2. First simulation: possible landslide events in the upper part of the Boite Valley (Gregoretti, 2014).

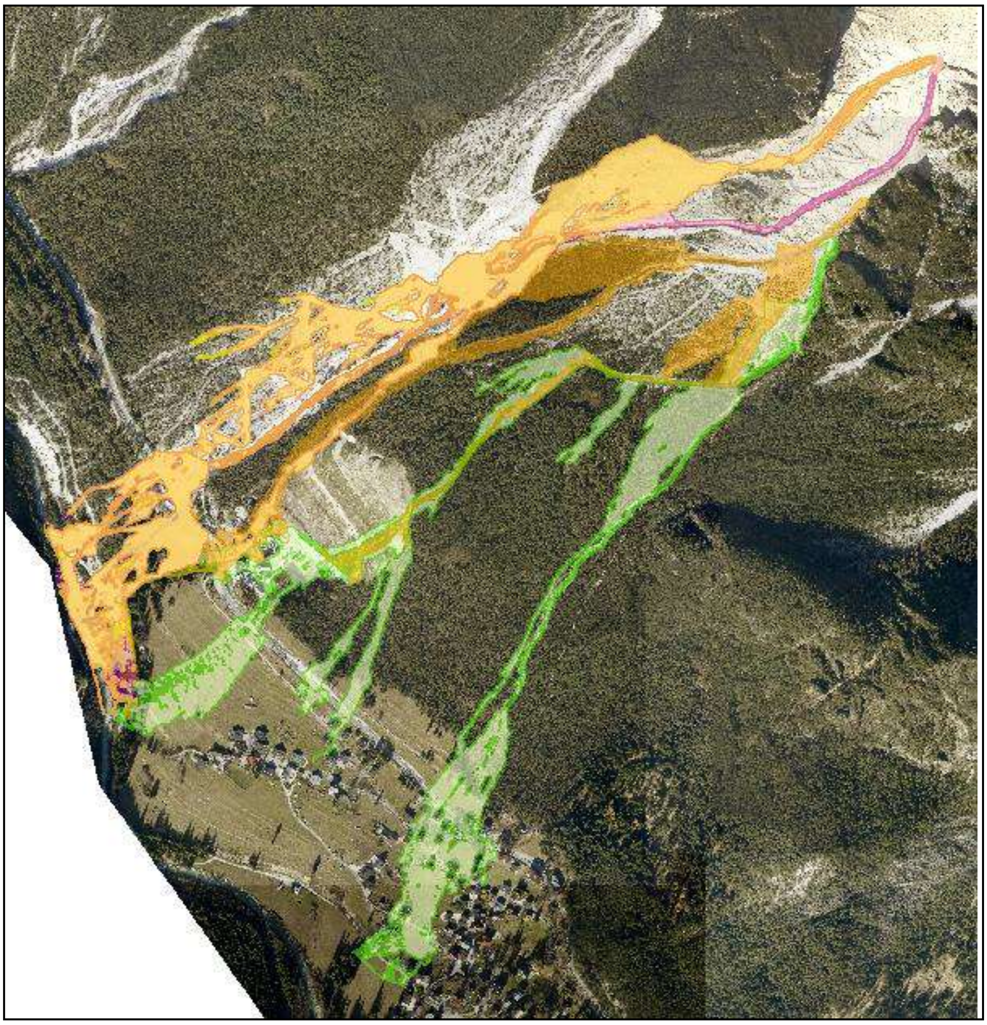

Figure 3. Second simulation: a possible landslide with (only yellow area) and without channel (yellow and green areas) in site 2 – Chiappuzza (Gregoretti, 2014).

3.3 *Sampling procedure*

An initial version of the questionnaire was tested on a sample pilot of 30 respondents. After the necessary amendments, the full-scale data collection was carried out in September-October 2014 by in-person surveys. 250 respondents were randomly sampled on-site among the residents and the visitors of the valley. The two identical repetitions of the DCE per respondent produced a total of 3,000 choice observations.

Regarding socio-economic characteristics, the sample consisted of 133 men (53.2%) and 117 women (46.8%). The respondents were all aged between 18 and 92 years. The average age was 47.7 years, respectively 49.5 for men and 45.8 for women. Almost half of the sample was resident in the valley (43.2%, 108 respondents out of 250) and the other half was composed of different types of visitors (56.8%, 142 respondents). However, almost 90% of the respondents are residents in the Belluno province. The local scale of the investigation appears to be necessary because residents and people that live in the nearby valleys are the main beneficiaries of the policy implementation. A summary of the socio-demographic and economic characteristics of the sample is presented in Table 3. More information regarding the geographical distribution of the sample is provided in section 4.2.

Variable	Description	Frequency	%
Age	Less than 30 years	29	11.6
	30-39 years	46	18.4
	40-49 years	64	25.6
	50-59 years	55	22
	60 or more	56	22.4
Gender	Male	133	53.2
	Female	117	46.8
Family members	Single	45	18
	Couple	68	27.2
	Three members	68	27.2
	Four members	56	22.4
	More than four members	13	5.2
Minor family members	No minor members	191	76.4
	One minor member	39	15.6
	Two minor members	17	6.8
	Three minor members	1	0.4
	More than three minor members	2	0.8
Education	Primary school	8	3.2
	Intermediate school	61	24.4
	High school	118	47.2
	Bachelor degree	15	6
	Master degree	43	17.2
	Post-graduate degree	5	2
Job position	Self-employed	42	16.8
	Employee	114	45.6
	Professional	18	7.2
	Businessman	12	4.8
	Student	11	4.4
	Housewife/retired/unemployed	53	21.2
Family income	Less than 15,000€	69	27.6
	15,000-30,000€	102	40.8
	30,000-45,000€	55	22
	45,000-60,000€	16	6.4
	More than 60,000€	8	3.2
Respondent type	Residents	108	43.2
	Second-house owner	12	4.8
	Daily visitor	92	36.8
	Overnight visitor	3	1.2
	Other (work, study, transit)	35	14

N=250

Table 3. Socio-economic characteristics of the sample.

3.4 *Econometric model*

In our DCE respondents are presented with two series of six choice sets, each containing various landslide protection scenarios, for a panel of 12 choice sets. Although respondents were asked to rank the scenarios from best to worst using a reiterated best-worst approach, in the analysis reported here we only use data on the most favourite alternative. Each choice in the sequence is modelled as a function of the attributes using Random Utility Theory (or RUT, see for example Luce, 1959; McFadden, 1974; Train, 2003).

Several RUT models have been proposed in literature, and most recently focussed has been placed on those able to relax the independence of irrelevant alternative assumption, such as Mixed Logit models (Train, 1998; Revelt and Train, 1998). In this paper we adopt a Mixed Logit specification in WTP space (Train and Weeks, 2005; Scarpa et al., 2008). The utility function for choice occasion *t* is specified as:

$$U_{nit} = \lambda_n^* \left(\omega_n' X_{nit} - p_{it} \right) + \epsilon_{nit} \qquad \text{(Eq. 1)}$$

where *X* is a vector of non-monetary attributes, p_{it} is the cost attribute and ω_n is a conformable vector of marginal WTPs for each non-monetary attribute and respondent *n*. λ_n^* is defined as $\lambda_n \delta_n$, where λ_n is the scale of the i.i.d. Gumbel error $\varepsilon_{nit.}$ and δ_n is the realization of the cost coefficient for respondent *n*.

To test the first hypothesis that visitors and residents perceive the current level of protection from landslide hazard as inadequate, we included in our model the alternative specific constant (ASC) for status quo alternative. A negative sign of the ASC would support our hypothesis.

To investigate the substitution pattern of different protection devices a covariance structure was estimated to account for correlation across the elements of the vector ω_n:

$$\Lambda = \begin{bmatrix} \sigma_{b,b} & & & \\ \sigma_{c,b} & \sigma_{c,c} & & \\ \sigma_{s,b} & \sigma_{s,c} & \sigma_{s,s} & \\ \sigma_{v,b} & \sigma_{v,c} & \sigma_{v,s} & \sigma_{v,v} \end{bmatrix} \qquad \text{(Eq. 2)}$$

where σ are standard deviations of random parameters, *b* denotes basin, *c* denotes channel, *s* denotes sensor and *v* denotes video camera.

One of our main hypotheses was that a protection device would be valued more after respondents received detailed information about it (hypothesis H2). In order to test such hypothesis, ~~one can~~we estimate a utility function on the pooled choice data (pooling before and after information provision) and include one interaction variable between each attribute and a dummy variable *I*, which is defined as equal to 1 for data collected after the exposure to information. The generic linear utility function for the alternative *i* in the pooled data can be expressed as:

$$V_i = \omega_n' X_i + \Delta_n' (X_i \times I) \qquad \text{(Eq. 3)}$$

where X_i is the vector of attributes. A statistically significant element Δ_n will support the hypothesis of an information treatment effect on value.

To test the hypothesis of spatial heterogeneity of benefits associated with safety measures (H3), we represented the geographical distribution of mWTP across the region. We first simulated $mWTP_n$ population distributions by generating 10,000 pseudo-random draws from the unconditional distribution of the estimated parameters and calculating individual-specific estimates for each draw (Train, 1998; von Haefen, 2003; Scarpa and Thiene, 2005). We then sorted the values by municipality and computed the respective means. Finally, we mapped mean values with ArcGIS to obtain the geographic distribution of estimates in each municipality.

4. Results and discussion

4.1 *Model estimation*

The Mixed Logit (MXL) model in WTP space has been estimated by simulated maximum likelihood using Biogeme software (Bierlaire, 2003). The choice probabilities are simulated in the sample log-likelihood with 500 pseudo-random draws of the modified Latin hypercube sampling (MLHS) type (Hess et al., 2006). All the attributes' coefficients, as well as the alternative specific constant (ASC) for the status quo option, are assumed to have a normal distribution. The specification includes interaction terms between each attribute and the perception of information, coded as a dummy variable (0 = before receiving the information, 1=after receiving the information). For comparison, a Multinomial Logit (MNL) model and a Mixed Logit in preference space model have also been estimated. The information criteria for the three models are presented in Table 4. All information criteria are concordant to indicate that the specification in WTP space outperforms the others in terms of goodness-of-fit, suggesting that this model is better suited to explain the observed dependent variable and to capture the heterogeneity of respondents' tastes.

N = 250	MNL	MXL in preference space	MXL in WTP space
lnL	-3041	-2459	-2403
AIC	6106	4870	4758
BIC	6148	5051	4939
AICc	6107	4850	4738

Table 4. Models comparison.

The estimated parameters of the MXL model in WTP space are shown in Table 5. The estimated mean/median value for the coefficient alternative specific constant for the *status quo* is negative (-1.98±1.9), which suggests that respondents are generally benefitting from improved protection, and are ready to pay to achieve it. The construction of a channel is associated with the highest mean WTP value (€2.12±0.92) followed by the construction of a basin (€1.83±0.7). Respondents seem therefore to prefer passive devices. However, the construction of active devices is perceived as beneficial as well, as both devices of this kind are associated with positive WTP values, with sensors slightly preferred to video-cameras (€1.26±0.42 and €1.19±0.57). Both the negative perception of *status quo* and the positive WTP values for implementation of new devices support our first hypothesis.

We investigated the effect of the information provided by simulation scenarios by means of interaction terms between each attribute and post-treatment indicator variable, which took the value 1 for choices collected after the information treatment. The coefficients of the interaction terms with the attributes are all insignificant, with the exception of the interaction term for the attribute channel. This suggests that the information treatment led to a change of the perceived benefit from improvement only for this attribute. This result is consistent with the fact that one of the landslide simulations provided was focused on a possible building of a channel in one of the areas under study. It supports our hypothesis of a positive information effect on the perceived safety measure of those alternatives singled out for information provision. Specifically, the positive sign of the significant interaction coefficient suggests that after the information provision, respondents valued the benefit derived from the channel 42 cents. We did not find evidence, instead, of information effect for devices for which additional information was not provided. Therefore, hypothesis 2 is partially rejected.

Finally, it is interesting to note that the interaction term between the ASC for the *status quo* and the dummy variable for the information treatment is also significant (*p*-value 0.03), which suggests that after receiving information respondents change their perception of current protection measure. In particular, the negative sign of the coefficient associated with the interaction term (-0.15) suggests that respondents value even less the current scenario.

	Value	**Std. Err.**	***p*-value**
Mean parameters			
μ BAS	1.83	0.36	<0.001
μ CHAN	2.12	0.47	<0.001
μ SENS	1.26	0.21	<0.001
μ VIDEO	1.19	0.29	<0.001
μ ASC_SQ	-1.98	0.97	<0.001
μ ln(λ)	-2.05	1.12	<0.001
Interaction parameters			
Info × BAS	0.13	0.16	0.24
Info × CHAN	0.42	0.2	<0.001
Info × SENS	0.34	0.31	0.19
Info × VIDEO	0.08	0.14	0.56
Info × TOLL	0.04	0.24	0.81
Info × ASC_SQ	-0.15	0.09	0.03
Standard deviation parameters			
σ BAS	1.21	0.35	<0.001
σ CHAN	1.36	0.38	<0.001
σ SENS	0.99	0.41	<0.001
σ VIDEO	1.01	0.58	<0.001
σ ASC_SQ	0.87	0.63	<0.001
σ ln(λ)	1.81	0.95	<0.001
Log-likelihood	-2402.88		

Table 5. Estimates of the MXL model in WTP space.

Table 6 reports the estimated correlation terms among attributes coefficients, which illustrates the perceived substitution pattern of protection devices. Most of the correlation terms (four out of six) are statistically significant and all of them are positives. This suggests that different devices are considered substitutes of each other. We note that the highest correlation is found to be between protection devices of the same class. In particular, the highest degree of substitution has been found between channel and basin (0.68) which are both passive devices.

	BAS	CHAN	SENS	VIDEO
BAS	1.00			
CHAN	**0.68**	1.00		
	(0.18)			
SENS	0.12	**0.08**	1.00	
	(0.13)	(0.02)		
VIDEO	**0.02**	0.06	**0.29**	1.00
	(0.01)	(0.09)	(0.11)	

Note: Bolded values are statistically significant at 95%. Standard errors are reported in brackets

Table 6. Correlation among the random coefficients associated with non-monetary attributes.

4.2 *Geographical representations*

This section explores the geographical distribution of benefits that would derive from policy measures aimed at increasing landslide protection in the Boite Valley.

The sample covered 31 out of 67 villages on a 3,678 km² surface of Belluno province (209,430 inhabitants). From the total 250 respondents, almost 90% (89.6%; 224 out of 250) were resident in the province. The other 26 came from other parts of Italy, but mostly within the same administrative region (Veneto Region). Due to the low number of respondents from other provinces, we considered only the municipalities in the Belluno province. Moreover, people living in or close to the valley are more likely to be affected by the implementation of future mitigation projects. The average WTP value for each municipality was computed by averaging the respondent-specific estimates across residents in each municipality. We used ArcGis 10.3 (ESRI, 2010) to create the maps.

Figure 4 illustrates the average WTP for the construction of a channel, before and after information provision. We focus on this attribute as it was the only one affected by the information treatment. The map on the left illustrates the geographical distribution of mean WTP before receiving the information treatment, whereas the one on the right illustrates the values after such treatment. The maps provide some evidence of spatial heterogeneity of the estimates, as values change in different areas of the region, thus supporting our third hypothesis. However, there does not seem to be a strong evidence of a distance-decay effect on the estimates, as high WTP values were retrieved also in municipalities located far from the Boite Valley. However, most of the municipalities that show a high marginal WTP value are located in mountain areas and in the province where there is a real risk of landslide. We notice a general increase in the post-information mean value of WTP in almost all municipalities, which is consistent with population estimates. Before information provision in most of the municipalities the average WTP values are between €1 and €2, followed by values between €2 and €3. Only one municipality exhibits WTP values higher than €3. After information provision, instead, most of the municipalities have values within €2 and €3. Additionally, there is also an increase in the number of municipalities with WTP values higher than €3. Information seems to affect residents of Boite Valley and those living in municipalities on the East border. An increase in the perceived value after information provision is also detected in some municipalities in the southern part of the province, which is far from the valley. Individuals living in this area are likely to have lesser knowledge of the landslide problem of the Boite Valley, which may explain the strong effect of the information treatment among them.

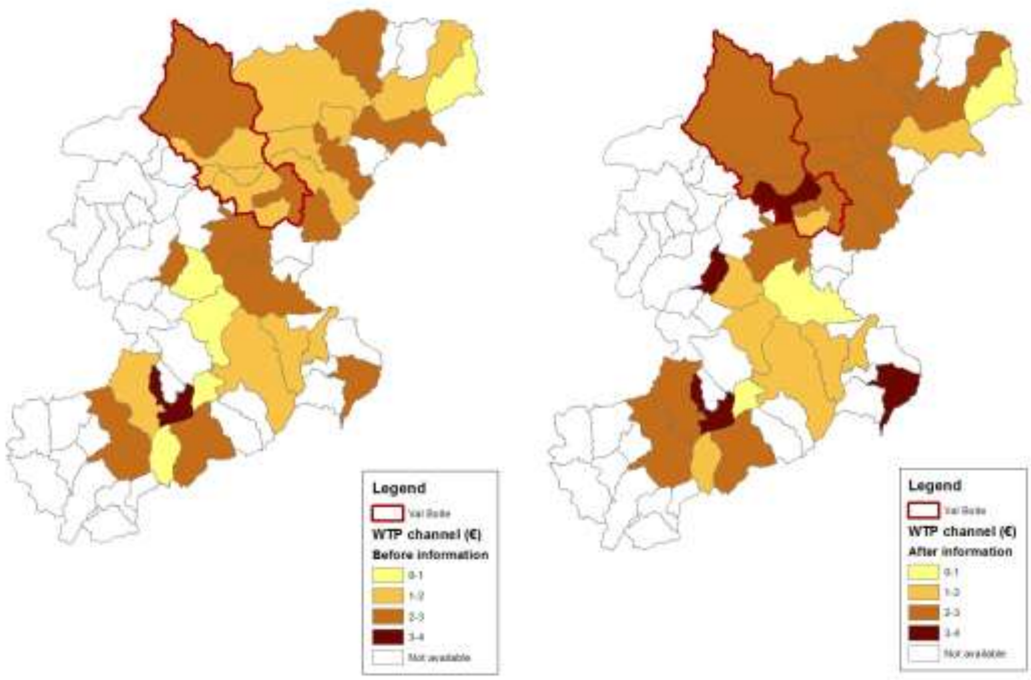

Figure 4. Mean WTP for the attribute "channel" (before on the left, after on the right).

5. Conclusions

In this study we presented the results data analysis from a DCE designed to evaluate alternative protection actions in the context of landslide risk reduction. The study provides salient indications regarding both the effect of additional information and geographical distribution of WTP estimates. Our study was motived by three hypotheses: i) current safety measures are perceived as inadequate; ii) information provision positively affects individuals' mWTP for safety measures; iii) there exists spatial heterogeneity of both mWTP and information provision effect.

In support of our first hypothesis, we found that surveyed residents and visitors perceive negatively the *status quo* and have positive WTP valuations for the proposed improvements of the existing protection systems. In particular, passive devices are preferred to active ones. Results show evidence of nested substitution effects among protection measures, within the categories of passive and active devices. In partial support of our second hypothesis, we found strong evidence of a positive treatment effect linked to the provision of visual information regarding a specific action. Differently from other studies, the information does not have additional effects (positive or negative) on the attributes about which no additional information was provided. However, a change in the perception of the *status quo* was also detected since respondents appear to value current safety measures less after receiving information. As far as it concerns our third hypothesis, the mapping of the geographical distribution of WTP estimates provides some evidence of spatial heterogeneity of WTP values, although there are no immediately distinguishable spatial patterns. This suggests that the benefits associated with the construction of a channel are perceived differently by people living in different areas. The comparison of the geographical distribution of values before and after information showed which municipalities are to benefit most from increased awareness. In particular, the information effect appears to be substantial in areas located far from the Boite Valley, in which respondents are more likely to be least familiar with the local landslide issue.

With regards to the policy implications, the estimated mean values of marginal WTPs offer insight on the relative importance of each protection device. Having information about individual preference of local residents is important to public decision-makers to avoid controversies. The results of this study suggest that policymaker should focus on the implementation of plans which include the construction of passive devices, as residents and visitors of the Boite Valley are willing to contribute more to their realisation. In particular, as passive devices seem to be strong substitutes, it seems appropriate to promote the construction of channels as it is associated with the highest WTP values, even before information provision. With regards to the effect of information, it appears that better-informed respondents make choices consistent with higher willingness-to-pay which are specific to the policy measure for which the information is provided. This unsurprising result suggests that investment in education may be appropriate to increase people’s inclination to contribute to the implementation of specific actions. In particular, it may be useful to focus such campaigns on civil engineering measures that policymakers plan to adopt. The analysis of the geographical distribution of the benefits may have important repercussions on the scheme to be adopted to apportion protection costs locally. Specifically, accounting for the spatial heterogeneity of individuals’ preferences might induce a broader acceptance of a public intervention and support (i.e. cost-sharing) over a broader geographical area. Despite these interesting conclusions, these estimates should be used with caution. These results should be integrated with a cost-benefit analysis for an efficient decision-making tool in risk management policy.

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